

**PHYSICAL AND BIOTIC CORRELATES OF POPULATION
FLUCTUATIONS OF DOMINANT SOIL AND LITTER ANT
SPECIES (HYMENOPTERA: FORMICIDAE) IN
BRAZILIAN COCOA PLANTATIONS**

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Abstract.—The relation between weekly patterns of percent occurrence of dominant ant species in litter and soil samples from a Bahian (Brazil) cocoa plantation and climatic factors was examined. No significant lagged correlations were found for the litter dominants, however the soil dominant *Acropyga* cf. *paramaribensis* showed significant lagged correlations with temperature, rainfall and leaf flush, probably in response to increases in the populations of their mutualistic root mealybugs. Population fluctuations of *A.* cf. *paramaribensis* were found to be highly associated with those of the other soil dominant *Tranopelta* sp., which we believe to be a predator of the dominant and its mutualistic mealybugs.

Because of the modular nature of ant colonies (Andersen, 1991), worker populations vary more than do colony densities. These population fluctuations should be in response to resource availability, which should be strongly influenced by abiotic factors. Alternatively, population fluctuations could be due to interactions among members of the community, but probably still in response to resource availability. Ant communities are thought to be organized through competitive relationships (Fowler and Claver, 1991), and the occurrence of numerically dominant species necessarily limits resource availability for the remaining species of the community, as well as controls the upper limits of species numbers (Tilman, 1982).

Tropical ant communities have high faunal richness (Andersen, 1991). Of the 124 ground ant species recorded in a Bahian cocoa plantation, *Solenopsis* sp. A, *Wasmannia auropunctata* (Roger), *Solenopsis (Diplorhoptrum)* sp. B, and *Carebarella* sp. were dominant in the litter stratum, and *Acropyga* cf. *paramaribensis* Borgmeier and *Tranopelta* sp. were dominants in the soil stratum (Delabie and Fowler, 1992). This strong dominance structure is not characteristic of tropical areas (Andersen, 1991), and the causes of these patterns are important components for an understanding of the organization of community structure (Tilman, 1982). The remaining ant species of these cryptic communities were collected only occasionally, and, thus, their importance in structuring these communities may be limited. Here, we address the following questions: [1] does weather have any relation to the population fluctuations of the dominant ant species?; and [2] do strong interactions exist among the dominant ant species? Either or both of these could produce changes in community structure.

METHODS AND MATERIALS

From June, 1986 to December, 1987, in an area of 0.83 ha on the Cocoa Research Station in Itabuna, Bahia, Brazil, 51 15 × 15 × 15 cm weekly soil samples were collected immediately below the litter layer. Each sample was taken 1.5 m from the trunk of one of 500 randomly chosen numbered trees. Ants were immediately extracted by hand sorting, and afterwards two successive sifters (2 and 1 mm mesh size) were used to extract ants not visually detected. Ants were preserved in 70% alcohol for subsequent identification in the laboratory.

Litter samples were collected at irregular intervals from February, 1987 to October, 1988, in the same experimental area, using the same sampling procedure. For each sample, a randomized 1 m² of litter near the trunk of a numbered tree was also collected, and its depth measured. These samples were extracted in a Berlese funnel for 48 hours, and then preserved in 70% alcohol and identified as in the soil samples.

For both soil and litter samples, we recorded species presence. Data were then transformed into percentages (number of samples per species/51 weekly samples). For both sampled strata, we compared only the dominant species, defined through species rank-abundance plots, using a criterion of 10% occurrence as a minimal value (Delabie and Fowler, 1992).

We correlated the weekly percentage of samples containing dominant species against data from the nearby Cocoa Research Center weather station. Data were smoothed by a 3 point moving average, and were then successively lagged for correlations. We regressed monthly percentage occurrence of the dominant soil species against each other.

RESULTS

Dominant litter species were *Solenopsis* sp. A (44.03%), *S. (Diplorhoptrum)* sp. B (13.82%), *W. auropunctata* (10.07%) and *Carebarella* sp. (10.07%), while for soil, dominant species were *A. cf. paramaribensis* (58.07%) and *Tranopelta* sp. (13.17%).

No significant correlations were found for any of the dominant species with temperature or precipitation (Fig. 1). However, a strong peak occurrence frequency of *Solenopsis* sp. A was evident at the end of the summer (April) (Fig. 1). The other dominant ant species showed no apparent seasonal trends (Fig. 1).

Similar comparisons were performed with the dominant soil species with leaf flush and climatic conditions (Fig. 2). After data smoothing, *A. cf. paramaribensis* percent occurrence was positively correlated with precipitation at a 5 week lag ($r = 0.60$; $P = 0.001$), while temperature and leaf flush were positively correlated with ant populations at a 12 week lag ($r = 0.52$; $P = 0.001$ and $r = 0.51$; $P = 0.001$, respectively).

By regressing the numbers of each of the two species per month for two species (Fig. 3), a strong relationship was found:

$$y = 0.33x - 2.88 \quad (r^2 = 0.64)$$

where y = percent of *A. cf. paramaribensis* in the monthly samples, and x = percent of *Tranopelta* observed in the samples during the same period.

DISCUSSION

Two of the dominant litter species are facultatively dependent upon honeydew (*W. auropunctata* and *Solenopsis* sp. A). *Carebarella* sp. and *S. (Diplorhoptrum)* sp.

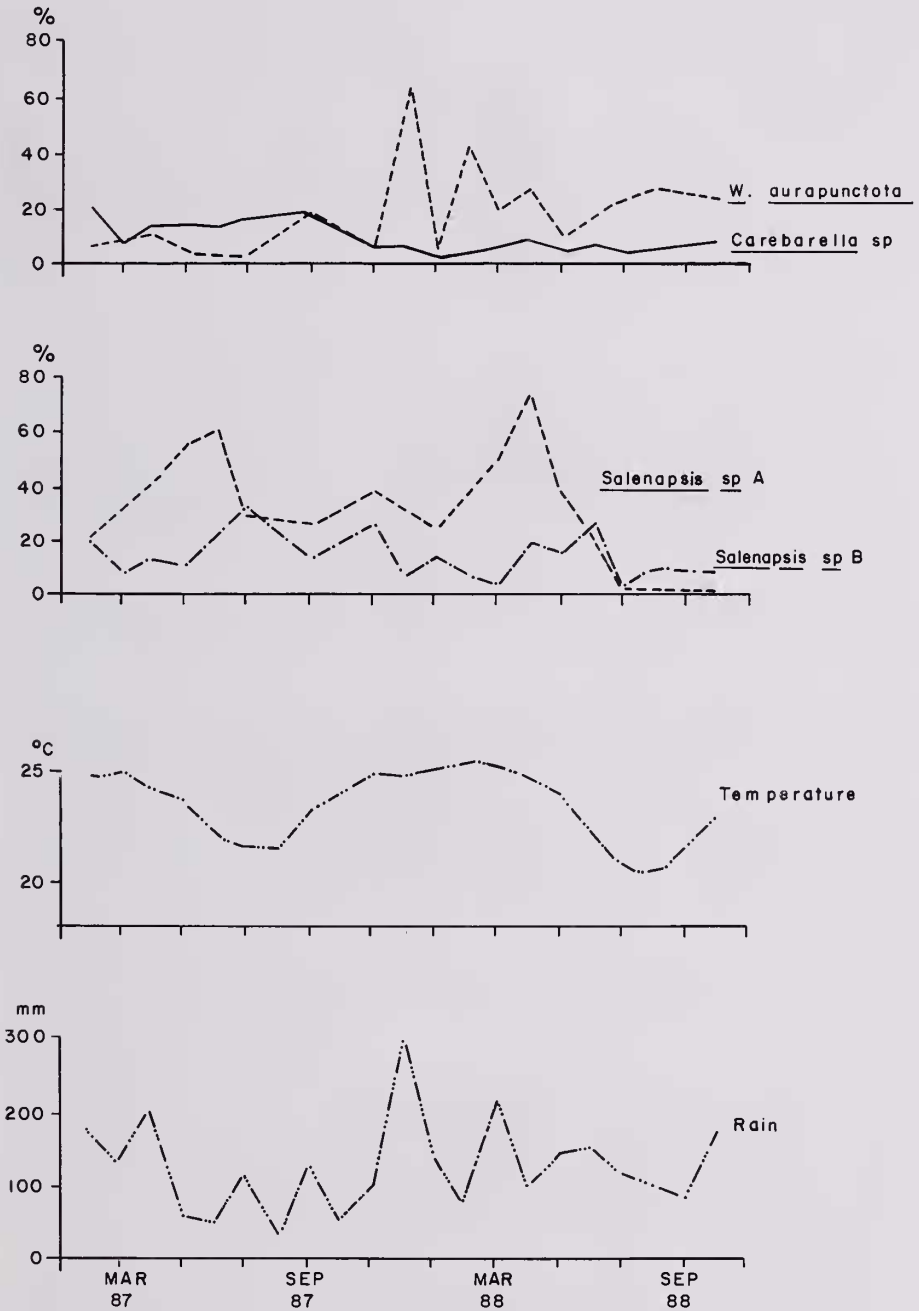


Fig. 1. Percent occurrence of the dominant ant species in Berlese litter samples over the study period, and corresponding air temperature and rainfall data.

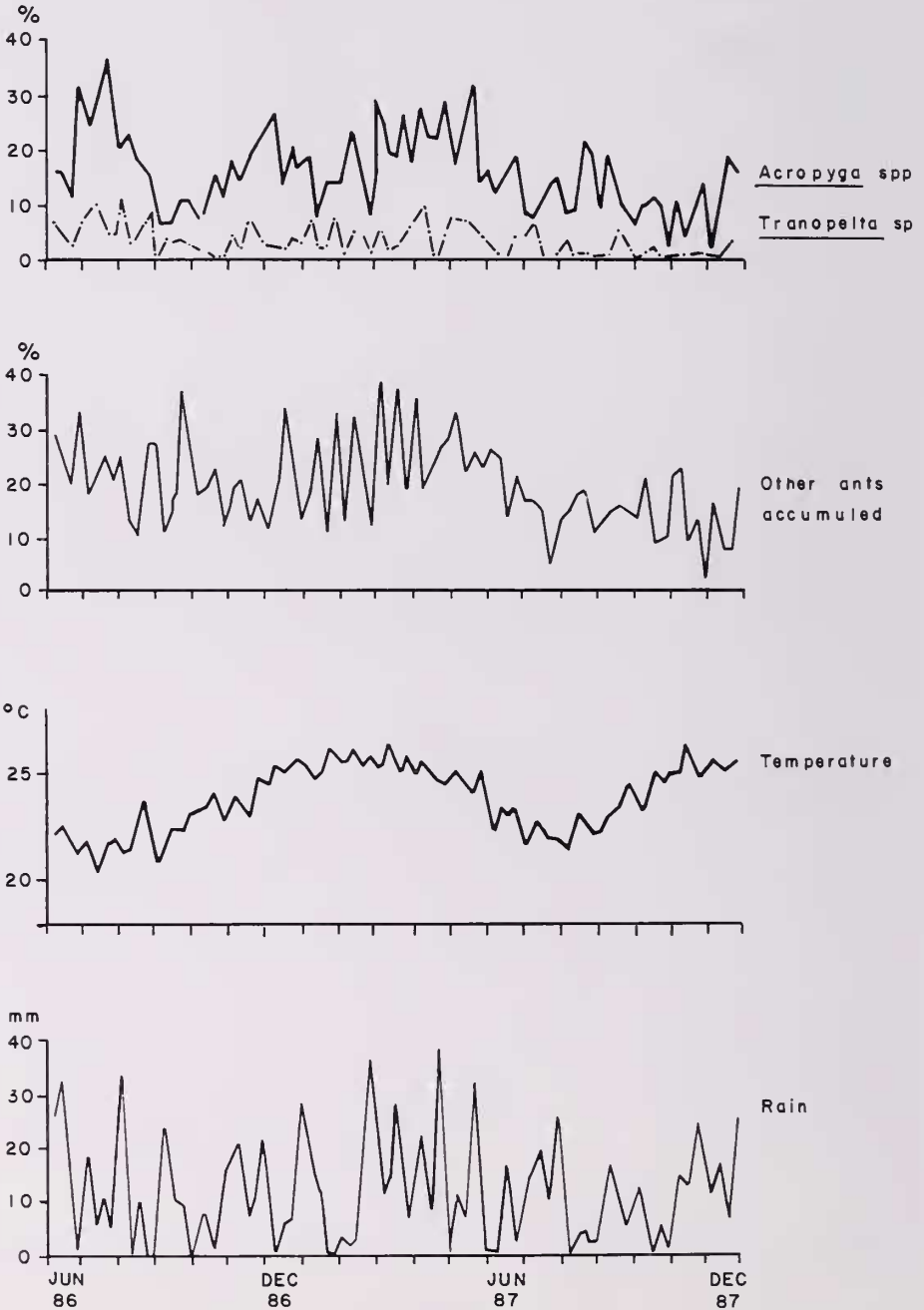


Fig. 2. Percent occurrence of the dominant ant species in soil samples over the study period, and corresponding air temperature and rainfall data.

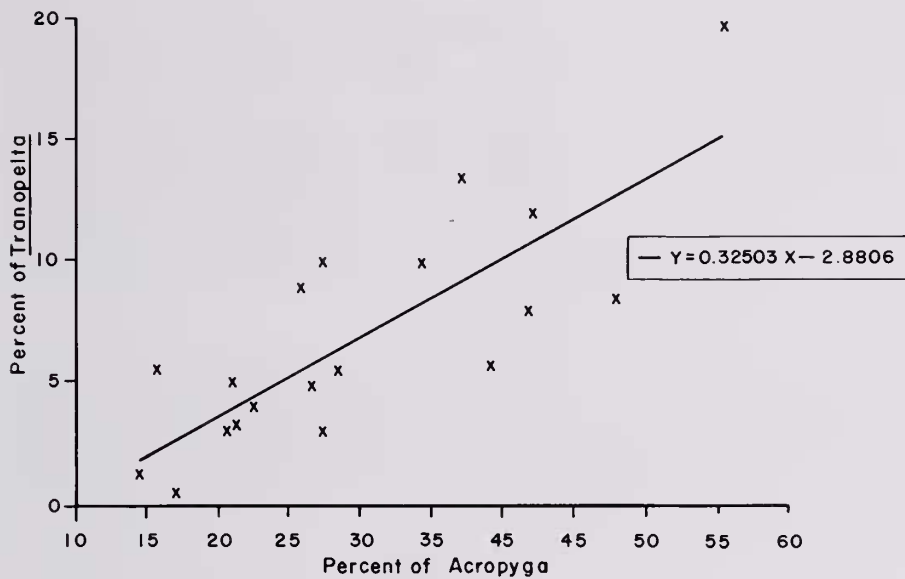


Fig. 3. The relation between the percent occurrence of the two dominant soil ant species over the sampling period.

B are both strictly carnivorous (Fowler et al., 1991), and foraging populations would depend on the type and abundance of prey present, which was apparently not directly influenced by climatic conditions.

We suggest that climate may indirectly influence the populations of *A. cf. paramaribensis* and its associated mealybugs. Climate influences both plant growth and leaf flushing, and we suspect that the mealybugs may have a greater physiological dependence upon the root's growth and turgor pressure, thus limiting the availability of food resources (Delabie et al., 1991). This may explain the 12 week lag in population response to temperature and leaf flush. The 5 week lag detected for population response to rainfall may indeed be an indication that humidity induces a quick population response of the associated mealybugs, and a corresponding increase of ant populations (Zanetti, 1992).

We have no information on the interrelations between *A. cf. paramaribensis* and *Tranopelta* sp. However, we suggest three possibilities to explain the positive correlations between population frequencies. The first possibility is that both depend upon mealybugs as a food resource. However, if mealybugs, or mealybug root substrate were limiting factors, this correlation should be negative to evidence competition. The second possible explanation is that *Tranopelta* preys upon *Acropyga*, but we have no evidence that this occurs. The data are, nevertheless, very reminiscent of typical predator behavioral functional responses. The third hypothesis is that both species are facultatively dependent, or that at least one species depends upon the other for either food or protection. This alternative was chosen in our regression model. *Tranopelta* sp. is a possible parent of the Solenopsidini tribe (Myrmicinae),

which is primarily predaceous, although some species will facultatively tend homopterans (Fowler et al., 1991). However, species of *Acropyga* (Formicinae) are entirely dependent upon root mealybugs as a food resource, forming one of the true mutualistic relationships among insects (Fowler et al., 1991). Therefore, we propose that *Tranopelta* may indeed protect colonies of *Acropyga*, and extract a tribute in either *Acropyga* workers or brood, or in symbiotic root mealybugs. Indeed, *Tranopelta* sp. is encountered much less than expected at both carbohydrate and protein subterranean baits (Fowler and Delabie, 1992), providing further indirect evidence for their facultative dependence. Obviously, controlled laboratory studies are needed to test these competing hypotheses.

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LITERATURE CITED

- Andersen, A. N. 1991. Parallels between ants and plants: implications for community ecology. Pages 537–558 in: C. R. Huxley and D. F. Culver (eds.), *Ant-Plant Interactions*. Oxford University Press, Oxford.
- Delabie, J. H. C. and H. G. Fowler. 1992. Soil and litter cryptic ant assemblages of Bahian cocoa plantations. *Pedobiologia* (in press).
- Delabie, J. H. C., J. E. Mantovani and I. Mauricio. 1991. Observações sobre a biologia de duas espécies de *Acropyga* (Formicidae, Formicinae, Plagiolepidini) associadas a rizosfera do cacauero. *Rev. Brasil. Biol.* 51:184–192.
- Fowler, H. G. and S. Claver. 1991. Leaf-cutter ant assemblies: effects of latitude, vegetation, and behaviour. Pages 51–59 in: C. R. Huxley and D. F. Culver (eds.), *Ant-Plant Interactions*. Oxford University Press, Oxford.
- Fowler, H. G. and J. H. C. Delabie. 1992. Resource partitioning among epigeaic and hypogaeic ants (Hymenoptera: Formicidae) of a Brazilian cocoa plantation. *Ins. Soc.* (in press).
- Fowler, H. G., L. C. Forti, C. R. F. Brandão, J. H. C. Delabie and H. L. de Vasconcelos. 1991. Ecologia nutricional de formigas. Pages 131–223 in: A. R. Panizzi and J. R. P. Parra (eds.), *Ecologia Nutricional de Insetos*. Editora Manole, São Paulo.
- Tilman, D. 1982. *Resource Competition and Community Structure*. Princeton University Press, Princeton.
- Zanetti, E. S. 1992. Características das comunidades de formigas (Hymenoptera: Formicidae) e suas interações com homópteros em pomares de cítricos. M.S. thesis, UNESP, Botucatu, SP, Brazil.

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